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ANTHROPOGENIC CAUSES OF SOIL EROSION IN RWANDA: A CASE STUDY

Dukuziyaturemye Pierre*

ABSTRACT

There is nothing in the whole non-living environment which can be taken intoconsideration as the soil. Truly it is through the soil that the world becomes a friendly environment for mankind. Rwanda's high population coupled with steep slopes, and abundant rainfalls have led to land degradation because of peasantry agriculture. Increased and inappropriate cultivation methods and the livestock activities have led to deforestation and overgrazing which have exposed the soil to serious erosion. Soil erosions main downstream effectsinclude the deposition of sediment and agricultural pollutants into water courses, disturbance of the ecosystems, adulteration of water tables, and wetlands ecosystems. Currently, the Rwandan government is mobilizing its people for erosion control and landmanagement, but the economy of country has been negatively affected due to soil loss. The objective of this research was to determine the man-made causes of soil loss in order to suggest appropriate method to tackle and manage the situation. To achieve this objective, the questionnaires, interviews, photography and observation check lists were applied to collect data, thereafter were analyzed qualitatively and quantitatively. Results indicated that the major anthropogenic sources of soil erosion related to human population activities, politics and economies, technology and culture. Finally, it was observed that the activities of local communities and their participation towards land protection will without doubt decrease soil erosion.

Keywords: Soil erosion, Anthropogenic, Land degradation, Deforestation, Overgrazing

* **Lecturer at University of Rwanda,School of Public Health - College of Medicine and Health Sciences,Kigali-Rwanda**

1. INTRODUCTION

Soil erosion is a natural and slow process occurs when topsoil is detached and transported from upstream to down-stream or from onsite to offsite. In farming concepts, soil erosion refers to the detachment of top soil and moving it away by the natural forces of erosion agents or through forces associated with human activities (Zook, 1994). Soil erosion has three-steps including the detachment, transportation, and deposition. All these steps take place through an intermediate which may be water or wind. The most commonly however, erosion is driven by rainfall. The soil erosion rises if the soil has no or very diminutive plants cover and crop residues which defends the soil from raindrop influence and slow down the runoff water and permits the surface water infiltration. Soil quality and physical structure can be affected by the loss of soil and leading to extreme conditions such as drought.

Soil erosion is a continental and intercontinental problem that rarely makes the headlines. Soil that erosion moves off now totals more than 22 billion ton a year worldwide; to get a feeling for how serious the problem is, consider that approximately 4.0 billion metric tons of topsoil is lost each year from US croplands and pasturelands as a result of erosion (Raven et al., 1998), water erosion alone causes the loss of 12% of the total soil in Europe. Similarly, 95 million and 500 million hectors of land are badly affected by erosion in North America and Africa, respectively. Economic losses from soil erosion in South Asia are said to have currently accumulated t 6.9 billion dollars (Hanyona, 2001). Soil erosion and land degradation caused the food insecurity for 2.6 billion people globally, and the situation is mostly terrible in East and sub-Saharan Africa(Sanchez, 2002). Also the loss of cultivable soil due to erosion was found to be a key socio-economic and ecological problem in Kenya (Fleitmann et al., 2007). Population growth and human activities often has been thought to be principal cause or exacerbate soil problems, including erosion and mineral depletion of the soil, both of which occurs worldwide (Ovuka, 2000). Many attribute farm technologies, techniques and culture, population pressure on land resources and urbanization (Ashby, 1985), lack of technological sophistication and lack of awareness to existence and accelerate soil erosion (Zimmerer, 2002).

Rwanda is a country characterized by agriculture of different crops and about 90% of the population engaged in agricultural sector (MINECOFIN, 2002). It has very high rural population

densities compared to other countries of East-Africa, lush vegetation due to high rainfall, and steeply sloping highlands. It is landlocked; and has rare natural resources and negligible industry. This country has been facing a big challenge of arresting land degradation that leads to loss of soils and leaving infertile soils that are responsible for unproductive agricultural farming. Land degradation appears in form of deforestation and unsustainable use of forests, poor cultivation practices accompanied with overgrazing of rangelands that have led to unsustainable agriculture in the country. Soil loss and land degradation have long been assumed to be severe and a major reason for the poverty and food insecurity in the country. Several researches have been conducted and focused on types and severity of erosion, and on mechanical and biological methods to reduce erosion. The results indicated that soil loss due to erosion is severe, ranging from 35 to 246 t/ha per year with most stations measuring over 100 t/ha per year. Erosion would remove the fertile topsoil if no anti-erosion techniques were used (König, 1994); it has noted that erosion caused a loss of productivity equivalent to 8 000 hectares per year, enough to feed 40 000 people in 1990 (Gasana, 2002). Some 77% of all cultivated land in Rwanda have slopes between 13% and 55% are classified under the category of "moderate to high erosion risk soils". In some cases, land with a slope of over 80% put under cultivation as a result of land scarcity. In fact, 39% of all cultivated land in Rwanda fall under the high erosion risk categories, 37.5% in the middle risk category and only 23.4% is classified under the "low erosion risk" and "very low risk" categories (MINAGRI, 2001).Soil erosion causes denudation of mountain and hill tops, decreases the soil depth, alters the soil structure and reduces the soil nutrients resulting in decreasing of the water holding capacity with consequent leaching of nutrients and associated acidification of the soil (Koning and Smaling, 2005). Heavy rains frequently occur in the mountainous regions of the country and cause serious erosion and subsequent soil sedimentation in the lower parts of hillsides, often causing significant damage to crops and destruction infrastructure such as roads and polluting the rivers and wetlands. Soil erosion has worsened due to continuous and uncontrolled cultivation, exploitation of marginal land and the lack of reliable soil conservation methods (MINITERE,2004).In the past, the government focused almost exclusively on controlling erosion to the exclusion of other soil management or improved agronomic practices. The construction of radical terraces promoted by the government would be more effective in reducing erosion compared to the erosion ditches and grass lines established in the 1980s. However, the construction of such terraces would require a significant amount of

labor and probably an intensive community-based programme with technicians and extension agents.

2. MATERIALS AND METHODS

This study was carried out in Karambi village located in Rulindo District, Base Sector, Rwamahwa Cell (coordinates: 1° 38' 6" S,29° 53' 10"E; Latitude: -1.609495 and Longitude: 29.918555). This village shares a common border with Nemba sector of Burera District in North and Cyungo sector of Rulindo District in East. According to its position, it would have tropical climate, but due to the altitude of the region, the climate is relatively temperate. This region is characterized by two rainy seasons around October - December and April-Jun and two dry seasons around January - March and July–September with annual average temperature of 20 ° C. High temperatures are observed in August where they reach 27 ° C in the middle of the day. During the rainy seasons, the region encounters concentrations of mists in the valleys in the morning and on the hilltops in the late morning. Rainfall normally reaches 1,243.3mm per year on average. This study was carried out from January to July 2010 and employed both qualitative and quantitative procedures. Qualitative information provided a more holistic picture on the sources of soil erosion. The quantitative methods were logically used when dealing with tabulation, presentation and analysis of data. The methods that were used in data collection included field observation, interview and documentary sources. Observation was done to see the states of land utilization, the techniques used in soil erosion control and taking photographic where possible. By interview, selected respondents were asked questions to find out what they do, think or felling about soil erosion.During data processing, relevant data to the objectives of the study were considered and transformed into meaning information for easy interpretation and understanding. This was done through tabulation. Therefore, data was processed and findings were presented in form of tables, for which conclusions were based. The photographs and pie charts were used to present the findings from the questionnaires, observation and interview. Qualitative and quantitative data obtained were statistically analyzed using Microsoft Office Excel package to generate pi-charts, graphs and frequency tables.

3. DATA PRESENTATION ANALYSIS AND INTERPRETATION

3.1. Demographic information of respondents.

Rwanda's population growth has been unprecedented from approximately 2.6 million in 1960 to 8.2 million in 2002. In 2007, it was estimated at 9.3 million, and is likely to reach 1.8 million in 2012. Annual population growth rate was 3.1 percent in 2002, but declined to about 2.6 percent in 2007. The population density is about 343 people per km^2, the highest in Africa, but in some districts like Rulindo it exceeds 500 people per km^2. The youthfulness of the population (48.6%) combined with the high population growth rate and density has had a significant impact on the land use system and soil erosion in the country (MINECOFIN, 2002).

Table 1: Occupation of respondents

Occupation	Masculine	Feminine	Total
Farmers	176	164	340
Unemployed	8	6	14
Retailers	4	5	9
Students	3	1	4
Total	191	176	367

Source: Fieldwork

With regard to the gender of respondents in this study, 176 out of 367 respondents (46.8%) were women, the remaining number (53.2%) that is 191 out 367 are men. Concerning the occupation of respondents, the majority of them (92.55%) claimed to be farmers, 3.73% are unemployed, 2.48% of them are retailers and 1.24% of respondents are students (Table 1).

Table 2: Age bracket of respondents used for the study

Age bracket in years	Percentages
Under 18	0.62
Between 18-65	86.96
Above 65	12.42
Total	100

Source: Fieldwork

In term of age, 0.62% of respondents were under 18, while the majority of respondents (86.96%) were between the age of 18 and 65. The number of respondents above the age of 65 was 12.42% (Table 2).

3.2. The perception of community on soil erosion

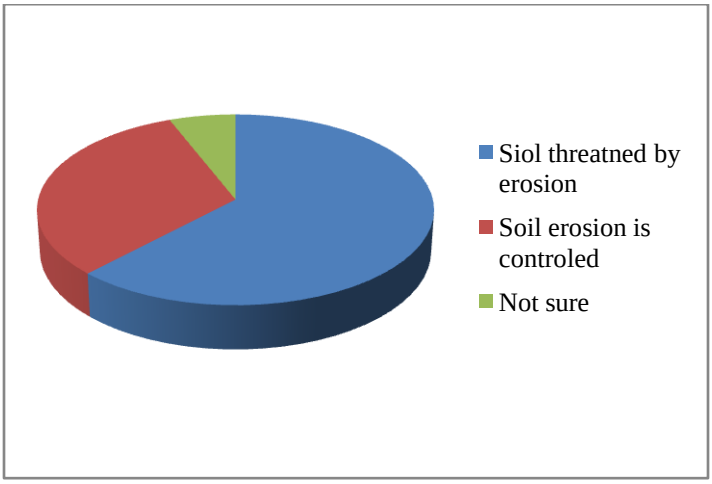

Figure 1: What residents think about the soil erosion?

Source: Fieldwork

Figure 1 shows that 62% of respondents indicated that their soil is threatened by erosion, 32% indicated that their soil erosion is controlled, while only 16% indicated that they are not sure.

3.3. Causes of soil erosion

3.3.1. Human Population

As the world population has increased, the human competition has had a growing impact on the environment of planet Earth. An example of this involves the influence of human activities on and around the earth‘s surface causingsoil erosion ten times more than naturally occurring processes.

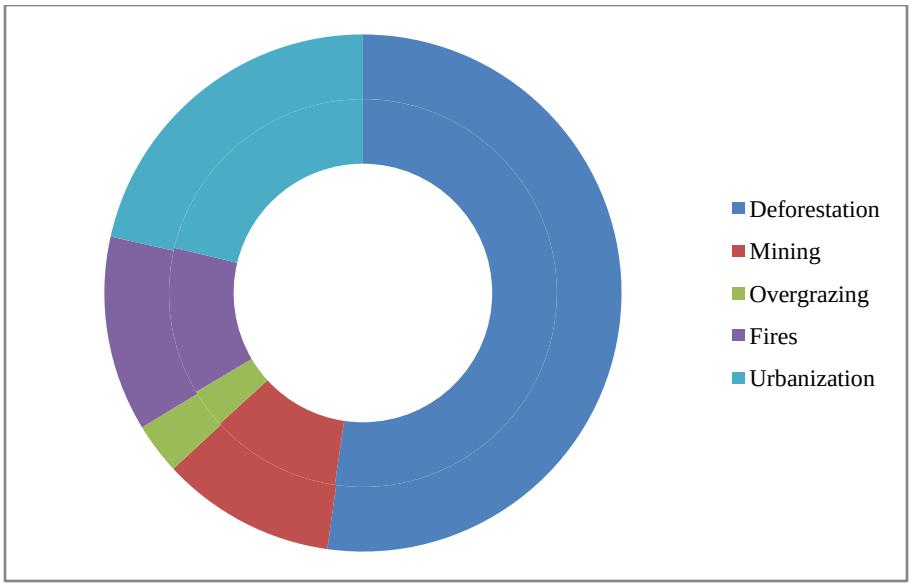

Figure 2: The activities of Human causing soil erosion
Source: Fieldwork

The prior activity leading on soil erosion in Karambi village is deforestation in which accounts for 27.2% of all respondents, the second is urbanization account for 21.2%, the third is fires of plants vegetation which has 12.3% and the less activities to cause soil erosion are mining and overgrazing which have 10.9% and 3.3% respectively.

Karambi and others village in Rwanda have been facing increasing urbanization. The Rwandese urban population has increased from 7% in 1993 to 18% of total population in 2002. The urbanization is estimated to grow by 30% by year 2020 (EDPRS, 2007). Human population increase, as well as increased rates of urbanization and agriculture in the region has increased the per capita demand for land, and hence more land is cleared to create the additional space leading to increased sediment deposition in the downstream (Odada et al., 2003). Forest and vegetation help avoid runoff or reduce soil erosion (Kayanja and Byarugaba, 2001); deforestation, over-grazing, and fire makes soil vulnerable to the erosion because this one occurs when the vegetation cover is disturbed or removed (Leila et al., 2009). The vegetative cover acts to reduce the velocity of the raindrops that strike the foliage and stems before hitting the ground, reducing their kinetic energy, (Goudie, 2000). Soil erosion is also accelerated by poor land management

practices such as continued overstocking resulting in overgrazing of pastures, indiscriminate slashing, cutting and burning of natural vegetation and population pressure (Ongwenyi et al. 1993). Urbanization and the construction of house contribute to soil erosion and increased sediment production in Karambi village. Urbanization has major effects on erosion processes first by denuding the land of vegetative cover, altering drainage patterns and compacting the soil during construction; and next by covering the land in an impermeable layer (Fuglestvedt et al., 2008; Keller 2005). In addition, severe fires and heavy grazing can lead to significant further erosion if followed by heavy rainfall.Miningalso increased soil erosion at the site of a mine, as well as the areas surrounding it (Goudie, 2006).

3.3.2. Politics and economies

The soil erosion is linked to the political and economic factors affecting land users. In South Africa apartheid policies ensured that 42% of the people lived on 13% of the land; this overcrowding has resulted in severe erosion. As the land became increasingly degraded and thus less productive, subsistence farmers were forced to further overuse the land.

Table 3: Political economy as cause of soil erosion

Elements of political economy	Number of respondents	Percentage
Small farms for cattle growing or keeping	59	16.1
Extension of agriculture into marginal area (small land size)	100	27.2
Intensive agriculture caused by reduction of landholding size	208	56.7
Total	367	100

Source: Fieldwork

Another cause of soil erosion in Karambi village is associated to the politics and economy. The results show that more than a half of respondents (56.7%) declared that intensive agriculture caused by reduction of landholding size cause soil erosion. The small farms for cattle growing

or keeping also causes soil erosion as 16.1% of respondents affirm it. The extension of agriculture into marginal areas (small land size) is likely to cause soil erosion; this is declared by 27.2% of respondents. According to Cunningham and Saigo (2001) in many developing countries include Rwanda, the land continues to be cheaper than other resources and is still being brought under cultivation.The intensive agriculture and overgrazing on small farms caused land degradation; mono-cropping of marginal lands unsuitable for cultivation has led to soil erosion. In the past 50 years, soil erosion and overuse of soils caused by intensive agriculture have damaged about 10% of the world's best agricultural land (Keller 2005); the soil erosion is more pronounced in the marginal lands as a result of intensive cultivation (Ongwenyi et al., 1993).Political and economy explanations of soil erosion in Karambi village emphasize that peasant farmers usually possess small farms and that these farms are of then located in erosion prone, marginal environments. The reduction of land holding size (about 0.6 ha per family) and the extension of agriculture into marginal areasmight induce erosion (MINAGRI, 2001).

3.3.3. Technology and culture

Explanations that emphasize the role of technology and land use practices in recent Rwandan soil erosion tend to link these conditions closely to culture. Lack of technological sophistication as tractors machine, lack of awareness about land utilization, loss of local knowledge have been pointed to as chief cause of soil erosion in Karambi village.

The technology and culture of farmers in study areais characterized by lack of technological machines (tractors), loss of local knowledge in land management, unsustainable agricultural practices, burning before cultivating, and lack of information about land utilization.

Table 4: Technology and culture as source of soil erosion

Technology and Cultural causes	Number of respondents	Percentage
Lack of technological machines (tractors)	192	52.3
Loss of local knowledge in land management	22	6
Unsustainable agricultural practices	108	29.4
Paucity of information about land utilization	37	10.1

Burning before Cultivate	8	2.2
Total	367	100

Source: Fieldwork

The poor using technological machines is related to location and position, the slope gradient and length of Karambi village. 52.3% of respondent without doubt said that due lack of tractors machine, they practiced traditional farming in which leading on the greater amount of soil loss from erosion by water. Not only that, unsustainable agricultural practices explained by continuous maize and beans production on the same land in Karambi village also are the single greatest contributor to the increase in erosion rates and in this study it account for 29.4% of all respondents.Mono-cropping, farming on steep slopes, pesticide and chemical fertilizer usage (which kill organisms that bind soil together), row-cropping are the sources of said erosion in the village.In addition, paucity of local knowledge in land management and lack of information about land utilization contributed to the soil erosion in this area. These causes affirmed by 6% and 10.1% of respondent respectively.2.2% of respondents agree that burning before cultivate leading on severe soil erosion in the study area because fire can destroy their soil protection (plant material and the litter layer). Pressed by economic conditions, many farmers have abandoned traditional crop rotation; continuous monoculture cropping can increase soil loss (Cunningham and Saigo, 2001).

SUMMARY

Soil erosion remains a key challenge for Rwanda agriculture. Increased population and development put greater stress on soils, overgrazing and poor farming techniques among others causes said above lead to soil erosion. Many farmers have already made significant progress in dealing with this calamity problem on their farms. However, because of continued advances in soil management and crop production technology that have maintained or increased yields in spite of soil erosion, others are not aware of the increasing problem on farmland. Awareness usually occurs only when property is damaged and productive areas of soil are lost. Soil must be protected from erosion as much as possible, with special attention to higher risk zones that leave the soil vulnerable to erosion.

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